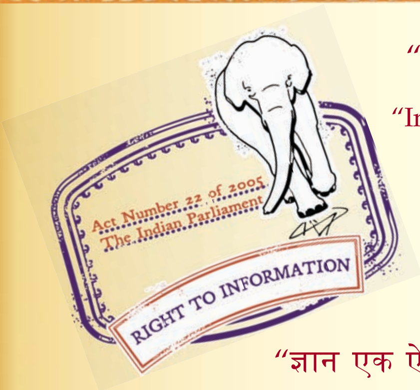
IS 11804 (1986): Code of practice for manufacture of aluminium alloy pressure die castings [MTD 7: Light Metals and their Alloys]



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Indian Standard

CODE OF PRACTICE FOR MANUFACTURE OF ALUMINIUM ALLOY PRESSURE DIE CASTINGS

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BUREAU OF INDIAN STANDARDS

MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG

NEW DELHI 110002

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Indian Standard
CODE OF PRACTICE FOR MANUFACTURE OF ALUMINIUM ALLOY PRESSURE DIE CASTINGS

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Indian Standard

CODE OF PRACTICE FOR MANUFACTURE OF ALUMINIUM ALLOY PRESSURE DIE CASTINGS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 30 July 1986, after the draft finalized by the Light Metals and Their Alloys Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 Pressure die casting in aluminium alloy offers means for very rapid production of engineering and other related components even of intricate design. The technique has obvious advantages when a component is required in large quantities. However, for engineering components such as those required for aeronautic space, defence and automotive applications, mechanical properties and durability are of primary importance. It is therefore essential that the best features of design should be employed and optimum casting technique with minimum cost be adopted.

0.3 In recent years, the pressure die casting in aluminium alloy, particularly the very fluid aluminium-silicon casting alloys has undergone rapid growth, in as much as the size of castings has also increased following the introduction of heavier machines. Aluminium silicon alloy because of its high fluidity and improved properties when subjected to modification are mostly selected for producing pressure die-cast components.

0.4 Because of its high melting point, aluminium alloy is subjected to die-casting in a cold chamber die casting machine. This in contrast to hot chamber process eliminates contamination of molten alloy with iron and also entrapment of air in the metal.

0.5 When supplies of die castings are required in accordance with this code, the purchaser should state that in his enquiry and order.

1. SCOPE

1.1 This standard covers the code of practice to be adopted in the manufacture of aluminium alloy pressure die castings.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Biscuit — The surplus metal from the injection cylinder of cold chamber machine which is attached to the runner. Also called slug.

2.2 Die Cavity — The impression in the die in the shape of required component.

2.3 Draft — The taper given to walls, cores and other parts of the die cavity to permit easy ejection of the casting.

2.4 Ejector Pins — Rods which force the casting out of the die cavity.

2.5 Gate — That part of the die through which the metal enters the die cavity from the runner.

2.6 Injection Cylinder — The chamber that in conjunction with the plunger, enables the molten metal to be forced into the die cavity.

2.7 Inserts — Shaped pieces, mostly made from hot die steel, which are inserted in the die and thus become integral with casting.

2.8 Over Flow Well — A recess in a die, connected to the die cavity by gate remote from entrance gate.

2.9 Parting Line — The plane or planes across which the die opens.

2.10 Plunger — The piston which operating in a cylinder forces the molten metal into the die.

2.11 Porosity — Voids or pores resulting from trapped air, gas or shrinkage in casting due to the excessive temperature of molten metal.

2.12 Pressure Die-Casting — A method of casting component by forcing molten metal under pressure into a split metal die on a die casting machine and the castings resulting from this process.

2.13 Runner — A channel in the die through which molten metal passes into the gate and subsequently fills the die cavity. This term is also applied to the surplus metal which solidifies in the channel.

2.14 Slug — *See* biscuit (**2.1**).

2.15 Spray — A casting or castings, complete with sprue or slug resulting from a single casting operation of 'Shot'.

2.16 Dimensional Stability — Ability of an alloy to remain unchanged in size or shape commensurate with die design.

2.17 Vent — Provision in the die to permit escape of air from die cavity or over-flow well.

2.18 Die-Cooling — Provision for circulation of water in the die to avoid subsequent over-heating.

2.19 Plunger Cooling — Provision for circulation of water through the plunger to avoid over-heating and to enhance plunger life.

3. DESIGN CONSULTATION

3.1 It is most essential to have initial and continuous co-operation between die caster and the purchaser till the design of the casting has been finalized.

4. MATERIALS AND COMPONENTS

4.1 General Requirements — Die cast components made from aluminium-silicon alloys for engineering applications should basically possess the required strength and soundness, durability, dimensional accuracy and corrosion resistance. While considering strength it is essential to take a note of those stresses which may be involved during assembly and also those which may well exceed those during actual operation. Provision will have to be made for the removal of certain components or parts thereof for periodical inspection.

4.2 Advantages and Limitation of Aluminium Silicon Alloy Die Castings — Pressure die casting in aluminium-silicon alloy offers a rapid method of production, specially when very large quantities of components are required. The fluidity of aluminium-silicon alloys permits intricate shape to be cast in thin section and with close dimensional tolerances. These castings have good physical and mechanical properties and require minimum machining. The alloys, being inherently corrosion resistant because of the formation of a continuous thin oxide layer, the cast component needs no extra protection. The limitation in the case of aluminium-silicon die-cast component is that they can be used for application at room temperature excepting in such cases where alloying additions like nickel, chromium, etc, are made. Such alloy die-cast component can be used at service temperature of 70 to 100°C as in the case of piston for internal combustion engine.

4.3 Choice of Alloy — Alloys, suitable for pressure die casting and their chemical composition and mechanical properties are specified in Table 1 and Table 2 respectively. Alloys 4600 and 4600A are widely used alloys for general engineering work and are suitable for pressure die casting. These alloys have excellent fluidity, good corrosion resistance, medium strength and can be cast in intricate shapes. The other two alloys, namely, Alloy 4420 and 4520 are also used for die-casting purposes depending upon the end use of the component and can be decided by mutual agreement between the contracting parties.

TABLE 1 CHEMICAL COMPOSITION OF ALUMINIUM ALLOYS FOR PRESSURE DIE CASTINGS

(*Clause* 4.3)

Alloy Designation	Chemical Composition, Percent (*Values Given Are in Maximnm Unless Shown in a Range*)										
	Copper	Silicon	Magnesium	Iron	Manganese	Nickel	Zinc	Lead	Tin	Titanium	Aluminium
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
4420	**3.0-4.0**	**7.5-9.5**	0·3	1·3	0·5	0·5	3·0	0·3	0·2	0·2	Remainder
4520	**0.7-2.5**	**9.0-11.5**	0·3	1·0	0·5	0·5	2·0	0·3	0·2	0·2	Remainder
4600	0·1	**10.0-13.0**	0·10	0·6	0·5	0·1	0·1	0·1	0·05	0·2	Remainder
4600A	0·4	**10.0-13.0**	0·2	1·0	0·5	0·1	0·2	0·1	0·1	0·2	Remainder

TABLE 2 MECHANICAL PROPERTIES OF ALUMINIUM ALLOYS FOR PRESSURE DIE CASTINGS

(*Clause* 4.3)

Alloy Designation	Condition	Mechanical Properties, *Min*			
		Tensile Strength		Elongation Percent on $5.65\sqrt{So}$ or 50 mm Gauge Length	
		Sand cast	Chill cast	Sand cast	Chill cast
		MPa	MPa		
(1)	(2)	(3)	(4)	(5)	(6)
4420	M	—	180	—	1·5
4520	M	125	150	—	—
4600	M	165	190	5	7
4600A	M	165	190	5	7

5. FREEDOM FROM DEFECTS

5.1 Aluminium-silicon alloy die-cast component should be free from blow-holes and pin hole porosity, shrinkage, cold shot, pour shot, etc. The class of radiographic quality of the die-cast component can be determined depending upon the end-use of component and should be mutually agreed to between the die-caster and customer. The die-cast component should be free from dimensional inaccuracies. No patching or welding shall be allowed to conceal or ractify any defects.

6. FINISHING

6.1 The die-cast components should be subjected to fetling operations for removal of gating system and fins, if any.

7. DIE DESIGN

7.1 To ensure complete satisfaction with the performance of any aluminium-silicon alloy die castings, careful thought has to be given to its die design, which should be established in mutual consultation between the purchaser and the die-caster. The die casting should be so designed that it not only meets the service requirements, but also permits easy and rapid production. Sudden changes in section and sharp corners should be avoided. It is preferable to use appropriate section thickness depending upon the geometry and end use of component. It is necessary that design should allow effective location of the gates, vents and overflow wells to die cavity to produce sound component. Thickness of section should be minimum consistent with adequate strength. The minimum wall thickness that is possible in aluminium-silicon alloy pressure die-cast components is 1·5 mm.

7.2 For mass scale production of aluminium alloy castings, ranging from 0·20 to 1·5 lakhs in quantity, dies are to be made from hot die steels using machining technique followed by spark erosion. For aluminium-silicon alloy the die steel should have a chemical composition of 5 percent chromium, 1 percent silicon, 1·3 percent molybdenum, 1 percent vanadium and 0·37 percent carbon and should be hardened to 425-460 HB. For prolonged use and life of the dies for making aluminium alloy casting the die is given a subsequent carburizing treatment.

8. WORKING PRACTICE

8.1 Choice of the Machine — Because of its high melting point, aluminium-silicon alloy is die cast in cold chamber pressure die-casting machine. The general principle of such machine is illustrated in Fig. 1. Metal for a single shot is loaded into a cylindrical chamber through a pouring aperture, a piston then forces the metal into the die, the entire operation being completed in a few seconds so that iron contamination is virtually eliminated. Using this technique much higher injection pressure in the range 70-140 MPa are feasible, enabling lower metal temperatures to be employed and greater intricacy achieved. The castings are also less prone to entrapped air and a higher standard of soundness ensures from the smaller amount of liquid and solidification shrinkage occurring within the die.

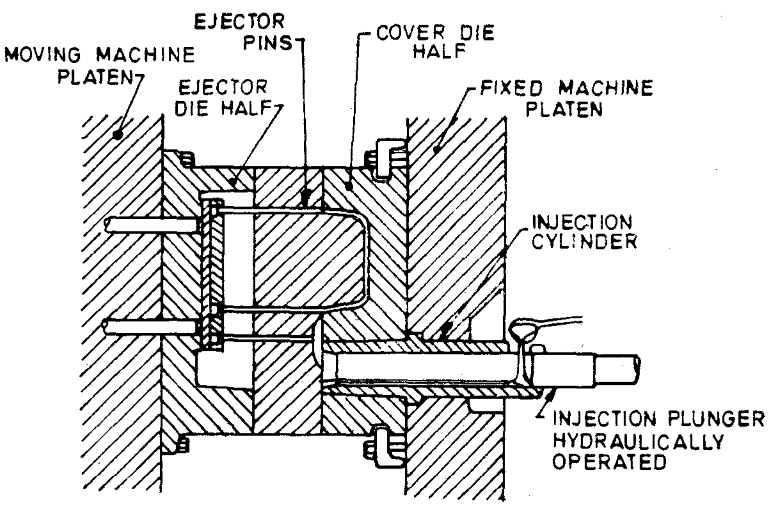

FIG. 1 COLD CHAMBER PRESSURE DIE CASTING MACHINE

8.2 In cold chamber operations the molten metal is usually maintained at constant temperature in an adjacent holding furnace; transfer of successive shots to the machine chambers can be accomplished manually. Holding furnaces may be electrically heated type or the one using immersion heating device, which has a close control over the molten metal.

8.3 Locking Mechanism — A crucial feature of any die-casting machine is the locking force available to keep the die closed against the injection pressure. The required locking force is determined by the projected area of the casting in the plane normal to the direction of closing; very high forces are required for some of the larger die-casting machines, now being produced. The basic principle of a typical machine is illustrated in Fig. 2. It can be seen that the die halves are mounted on a fixed and moving platen, the latter actuated by a hydraulic ram. Locking of the die assembly is accomplished by direct action of hydraulic ram, but hydraulic power is commonly combined with a mechanically acting toggle link system to reduce the pressure required and to safeguard the system in the event of hydraulic failure.

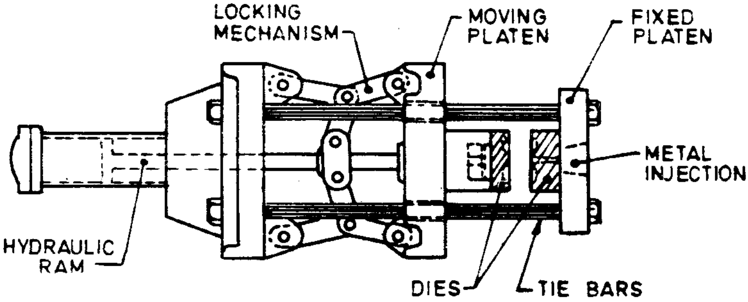

FIG. 2 BASIC PRINCIPLE OF PRESSURE DIE CASTING MACHINE

8.4 For satisfactory working and die life, the die temperature should be maintained within an optimum operating range depending upon the metal concerned; pre-heating is required at the beginning of a production run. Die temperature for aluminium-silicon alloy should be 250 to 300°C. The die temperature and rate of production are subsequently interdependent. For this reason a die face lubricant has to be used to prevent rising of temperature above optimum range. A thick suspension of graphite in oil is often used.

8.5 The selection of the capacity of a cold chamber die-casting machine will depend upon the size, shape, geometry and weight of the component. The machines should be able to provide ample capacity for the production of the component. Apart from the question of pressure on the

molten metal, the volume of metal displaced by the plunger per shot and the maximum permitted projected area of the casting should be taken into account.

8.6 Melting of the Alloy — The aluminium-silicon alloy ingots should be melted in an electrical resistance furnace having an automatic temperature controller. The molten metal should be thoroughly degassed by chlorine gas or hexachlorethane followed by modification with suitable modifier. For thinner sections the working temperature of the molten metal should be 680 to 690°C and for thicker section this should be between 650 to 680°C.

8.7 Die Temperature — The die temperature should be maintained such that castings of good quality are produced.

9. RECLAIMED METAL

9.1 The use of scrap in die casting should be avoided as far as possible. If scrap is to be used, the following conditions shall be observed:

a) Scrap used in the manufacture of die castings shall be derived from the supplier's own production from ingots of clean reject castings, free from inserts, together with clean-gates, spruce and overflow wells;

b) Castings with inserts may be used, provided the scrap is remelted into ingots and analyzed for purity; and

c) Where the purchaser so requires, the proportion of scrap to virgin alloys ingots shall be agreed to between the contracting parties.

9.2 It is recommended that normal maximum of reclaimed metal should be 25 percent, but it should never exceed 50 percent of the melt.

9.3 The accumulation of large quantities of scrap is undesirable because of the risk of contamination, but where accumulation is unavoidable, it is recommended that the metal be remelted into ingots and their composition determined. Dross, skimmings, swarf or sweepings should never be introduced directly or indirectly into the melting pot.

10. RADIOGRAPHIC EXAMINATION

10.1 Where internal soundness of a casting is vital, it is essential that the die-caster shall use radiographic examination in the development of casting technique.

11. IDENTIFICATION OF CASTINGS

11.1 Each die casting should bear a mark to identify the manufacturer of the casting. In addition, when multiple cavity dies are used, each impression should bear the distinguishing mark to identify its location in the spray. The location and size of these identifying marks should be as agreed to between the die-caster and the purchaser, and interference with the function or assembly of the component in question should be taken into consideration in this connection. Identifying marks should not, of course, be placed where they will be removed in any subsequent machining operation.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2